REMARKS/ARGUMENTS

The applicants acknowledge that claims 1-19 and 29-34 are pending in the application but claims 30-32 stand withdrawn from consideration pursuant to the Office's Restriction Requirement. The applicants reserve the right to file a divisional application.

Claims 4-19 stand rejected under 35 U.S.C. §112, second paragraph as failing to particularly point out and distinctly define the subject matter which the applicants regard as the invention. In response to this rejection, claims 4-19 have been amended to make clear that the applicants are claiming a property of the fullerene molecule or the trapped thermal neutron as the case may be, but claim 9 and 15 have been canceled. In response to the Office's rejection of claims 10 and 19, the claims have been amended to delete the term "or similar substance."

Claims 1-19, 29, 33 and 34, namely all of the claims under consideration, stand rejected under 35 U.S.C. §112, first paragraph, as directed to subject matter which is not adequately enabled by the description in the application. The applicant's vigorously traverse this rejection for the following reasons.

In making the rejection, the Office contends that the description in the application is not adequate because it does not teach how it is determined or insured that the thermal neutrons are actually caused to be trapped in the fullerenes and remain trapped in the fullerenes until they decay or they are utilized. The Office additionally rejects the claims because there is no disclosure of how and in what manner one can positively determine that the thermal neutron is actually trapped inside the fullerene as a free thermal neutron rather than being bonded to the fullerene.

Hereinbelow, the applicants provide a rebuttal to each of the cointentions that are being made by the Office. However, the applicants submit that the requirements that the Office is placing upon the applicants in the Official Action go well beyond the requirements that are sanctioned by 35 U.S.C. §112, first paragraph. As the Office is aware, the first paragraph of §112 requires that the applicant provide a written description of the invention and the manner and process of making and using it, in such full, clear, concise and exact terms as to enable any person skilled in the art to which it pertains "to make and use the same." The applicants submit that they have met this standard and that the additional requirements that the Office is arbitrarily establishing for this application are not mandated by the first paragraph of §112.

In the application the applicant has disclosed everything that is necessary to enable a person skilled in the art to make fullerene molecules containing free thermal neutrons. This is simple. Fullerene molecules are placed in a nuclear reactor and radiated by a steady-state thermal power

of between 10 and 500 kilowatts for a period of about 5 to 15 minutes. The applicants submit that this alone is sufficient to enable a person skilled in the art to make fullerenes entrapping free thermal neutrons. But, the applicants can appreciate the Office's contention that the teachings in the application in conjunction with the art must enable a person skilled in the art to identify the product. In that regard, the specification provides a detailed procedure for analyzing the gamma and beta emissions of the fullerenes to verify entrapment of the free thermal neutron. The sufficiency of these disclosures has been verified by Dr. Talnagi an expert in nuclear research from Ohio State University.

The Office contends that the teachings in the application relative to making the fullerenes and confirming neutron entrapment are insufficient. The Office contends the applicants must not only disclose how to make and verify but that the applicants must also prove that the Bemissions they are observing are not due to anything else. The Office expects the applicants to identify any and all other sources of B-emissions and verify that they are not the source of applicants' results. Since when was this a requirement of 35 U.S.C. §112. The Office's persistent questioning whether the applicants have in fact established that the thermal neutron is trapped in the fullerene without concrete evidence that applicants' methodology and analysis are defective is improper. The applicants have outlined a procedure for irradiating fullerene molecules with neutrons and verifying that the fullerenes exhibit the beta emission of trapped thermal neutrons. As the remarks below will more fully demonstrate, the hypertechnical verification of the invention is not reflected in any of the nuclear-related patents and literature that the Office has cited against this application. Accordingly, the applicants urge the Office to respect the limits of its authority under the first paragraph of §112 and to withdrawal the rejection.

Below, the applicants respond to the principal contentions underlying the §112 rejection:

> Contention: However, there is no adequate description nor enabling disclosure of how and in what manner, it is determined and ensured that thermal neutrons are actually caused to be trapped in the fullerenes and, to remain trapped in the fullerene until they decay or until they are utilized in any of the manners set forth in specification.

The presence of a beta emitter with a half-life of about 10 minutes with no associated gamma emissions is proof that the fullerene sample traps free thermal neutrons. No other known source of beta radiation was identified in the sample. Further, the applicants have demonstrated that simple neutron irradiation and activation of naturally occurring elements does not produce any other known source of pure beta radiation with the half-life characteristic of free thermal

neutrons. Finally, the applicants have shown that the only location for the trapped free thermal neutrons that is theoretically possible is inside the interior cavity of the fullerene molecules in the sample.

Although the examiner has cited peer-reviewed scientific papers and other patents that involve the trapping of various particles and atoms, none of these citations contains any description of the details of the trapping process beyond the bombardment of the sample target with the incident atoms or particles at some energy. In the case of the other patents, the Patent Office issued the patents without any of the anaylisis and verification that is being requested here. Hence no further disclosure should be or would be required here to enable one skilled in the art to practice the invention.

The applicants direct the examiner's attention to a paper appearing in Nature, vol. 403, 6 Jan. 2000, pg.62. This paper, by P. R. Huffman, et al. describes a macroscopic neutron trap that confines free, ultra-cold neutron within its interior cavity. Huffman's trap uses the neutrons' own magnetic field to accomplish this. With the exception of the applicants' 1995 patent application to the WPO and the present application to the United States Patent Office. This paper is the first published description of a magnetic means for trapping and storing free neutrons. Although the particulars of the respective traps are very different, Huffman demonstrates that it is possible to trap a neutron in a vessel using only a magnetic field. The applicants postulate that the electron cloud of a fullerene molecule may produce a repulsive magnetic field that can trap neutrons within the interior cavity of the fullerene molecule.

> Contention: More specifically, there is no disclosure of what causes a neutron from the beam of irradiating thermal neutrons, to penetrate only one wall of the fullerene and to not penetrate, contact, be absorbed in, etc., the opposite wall of the fullerene, such that it will remain trapped inside the fullerene as a free thermal neutron (there is also no disclosure of how and in what manner it is determined that such actually takes place as alleged in the specification).

First, there is no "beam of irradiating thermal neutrons" required to trap a free thermal neutron in the method described in the application. A nuclear reactor's thermal neutron flux is random. The energies of these incident thermal neutrons are infinitely variable over a very broad range in various reactor locations. Thermal neutrons, i.e., those with energies around 0.04 electron Volts (eV) are the predominant neutron population in the reactor location where the irradiation of the fullerene sample is conducted to produce the product of the present invention.

Secondly, at the atomic and sub-atomic scale, the terms "temperature", "kinetic energy," and "velocity" all implicate the same consideration. These terms refer to the relative motion of the fullerene molecule and the incident atom, sub-atomic particle, or thermal neutron at the instant of the collision. The ability of fullerenes to trap other particles is dependent on this relative motion. The papers and patents cited by the examiner establish this fact. All of the cited reactions depend upon the temperature or the kinetic energy of the incident particle or atom. Were the reactions not dependent on kinetic energy or temperature, these reactions would proceed at any temperature or kinetic energy. The fact is that some range of temperature or kinetic energy is required to drive these reactions in the art cited by the examiner. The fact that there is a minimum energy required for the reaction to proceed, in turn, indicates that there is some resistance to the atom, neutron, or sub-atomic particle entering the internal cavity of the fullerene molecule.

Thirdly, In the case of neutrons, "The Physics of Ultracold Neutrons by V. K. Ignatovich, ISBN 0-19-851015-2 and "Ultra Cold Neutrons" by R. Golub et al., ISBN 0-7503-0115-5, both contain lengthy and specific discussions of the established fact that there is resistance to neutron penetration of the surface of any solid. The science of "Neutron Optics" is the study of the

phenomenon that below a certain energy neutrons will reflect from a solid surface just as light does.

All of this indicates that below some minimum threshold energy, thermal neutron trapping does not occur because the neutron cannot penetrate the exterior surface of the fullerene molecule. The applicants do not dispute that above some maximum energy, the incident neutrons will simply pass right through both walls of the fullerene as the examiner suggests. But there is a finite range of incident neutron energies that will allow the fullerene molecule to trap the incident thermal neutron. There is a threshold, minimum, kinetic energy where the incident thermal neutron has just enough energy to penetrate the exterior wall of the fullerene molecule, it will reach the interior cavity of the fullerene molecule with insufficient remaining kinetic energy relative to the fullerene molecule to pass out of the fullerene molecule. Since the exterior wall has a threshold energy below which the neutrons will not penetrate it, it is completely reasonable to expect that the interior wall also has similar threshold energy. This is reasonable because, the neutron is penetrating the same wall in the opposite direction. The neutron crosses the same electron cloud of the same fullerene molecule in opposite directions. The range of incident neutron energies where trapping occurs is then between the first threshold energy to the sum of the first and second threshold energies. This is classical physics and something that would be apparent to a person of ordinary skill in the art of neutron irradiation. Given the gamut of neutron energies available in a reactor, some of the neutrons will have enough energy to enter and be trapped by the fullerene.

Although the level of understanding of the quantum physics details of the trapping process is limited; the conservation laws of classical physics accurately describe the gross characteristics of the process, as is noted above.

One may observe this same effect by firing shotgun pellets at plastic milk jugs. When the range to the jug and the size of the shot are just right, the pellets enter the interior of the jug but are unable to penetrate the opposite wall. The jug traps these pellets in the same way the fullerene molecules trap the thermal neutrons. The range of energies of incident neutrons in a nuclear reactor is such that some thermal neutrons will have just enough energy to enter the fullerene but not enough to exit. The fullerene molecules trap these neutrons.

Fourthly, the applicants have explained why the fullerenes molecules had to trap the observed neutrons within their interior cavities and the neutron is not in some other location. If a thermal neutron is not trapped inside the interior cavity of a fullerene molecule it is unrestrained. Its mean velocity relative to the fullerene molecules and the gross beta detector is approximately 2700 meters/second at room temperature. Any free thermal neutron not trapped by a fullerene molecule would not remain within the field of view of either instrument used by the applicants for more than 10^{-5} seconds.

Atoms and electrostatically charged particles may be trapped on the exterior surface of the fullerene molecule or within the lattice or cage-like wall of the fullerene molecule because they do form chemical bonds with the fullerene molecule. The papers and patents cited by the examiner describe this art. But, no art shows thermal neutrons are able to form chemical bonds. Neutrons cannot form chemical bonds so any process that relies on the formation of chemical bonds cannot trap them. It is conceivable that the electron cloud of the fullerene molecule could trap thermal neutrons. But if this happens, it cannot be the source of the beta decay observed by the applicants. This process would hold these neutrons too close to the carbon nuclei of the fullerene molecule. The carbon nuclei of the fullerene molecules are orders of magnitude more likely to absorb neutrons lingering in the electron cloud of a fullerene molecule than the neutrons are likely to survive long enough to decay. A neutron absorbed by any naturally

occurring nucleus does not produce the pure beta emission with a half-life of 10.25 minutes that is characteristic of free neutron decay.

No art shows that an individual free thermal neutron can survive outside of a fullerene molecule for more than a fraction of a second unless it is also in a vacuum. Outside a fullerene molecule, most nuclei rapidly capture any free thermal neutrons they may encounter. "Neutron Radiative Capture" or more simply "Neutron Capture" is the name of this art. Modern Physics thoroughly establishes this art. It too would be apparent to a person of ordinary skill in the art of neutron irradiation.

The carbon nuclei of a fullerene molecule are unlikely to capture thermal neutrons trapped inside the interior cavity of a fullerene molecule because the neutrons are unable to approach close enough to any of the carbon nuclei in the fullerene molecule. The probability of a carbon nucleus capturing a free neutron is very dependent on the distance between the neutron and the nucleus. The neutron "capture cross-section", i.e., the probability of capture by carbon nuclei, is small. The distance from the center of the interior cavity of the fullerene molecule to the carbon nuclei is about 3.5 angstroms according to Estreicher et al. This is unique. The nuclei of most atoms and molecules are about 0.5 to 0.75 angstroms from the surface of their electron clouds. The de Broglie wavelength of a thermal neutron is about 1.4 angstroms at room temperature. It is much more likely; that a neutron within one de Broglie wavelength of a nucleus will "tunnel" into the nucleus and be captured than a neutron that is three de Broglie wavelengths from any nucleus. This is why most nuclei rapidly capture thermal neutrons outside the interior cavity of a fullerene molecule. Inside the interior cavity of the fullerene molecule, the applicants expect that the interaction of the field of the nuclear magnetic moment of the neutron and the interior wall of the fullerene molecule traps the neutron near the center of the cavity. This is exactly analogous to Estreicher's hydrogen atom and the muonium of Percival

and Niedermayer that remain near the center of their fullerene molecules. This is why neutrons inside the interior cavities of fullerene molecules avoid capture by the carbon nuclei of the same fullerene molecule. They are never able to approach a nucleus so that the probability of capture is never more than infinitesimally small.

> Contention: There is no disclosure of how and in what manner, one can positively determine that the thermal neutron is actually trapped inside the fullerene as a free thermal neutron rather than being bonded to the fullerene or, even just be reflected among the carbon atoms present in the fullerene sample.

The applicants submit that this is not a requirement under 35 U.S.C. §112. §112 requires an applicant must enable what the invention is not. As discussed just above, the positive determination that the interior cavities of fullerene molecules trap free thermal neutrons is based in part on a deductive elimination of all the other options. For the beta decay to be observable, the movements of the neutrons must be constrained within the field of view of the detector but away from any nuclei. This means the neutrons cannot be outside the fullerene molecules or they would quickly escape the detector or be captured by any nuclei they happen to pass by closely. If the neutrons were attached to the outer surface of the fullerene molecules or within the lattice of the cage-like walls, the neutrons would be captured rapidly by carbon nuclei.

This option also assumes that neutrons can form something resembling a chemical bond. This is a behavior that has never been observed in neutrons. The applicants do not claim this neutron behavior. It is only within the interior cavities of the fullerene molecules that the movements of the neutrons are both constrained and the neutrons can maintain enough distance from any nuclei that they avoid capture by those nuclei.

A person with ordinary skill in the art of neutron irradiation would not expect to measure the neutron half-life directly from a simple neutron irradiation experiment for these exact reasons. However, once he followed the procedure in the application and saw that he could

measure this half-life with the procedure in the application, he would immediately grasp the significance and uniqueness of the applicants' experimental procedure.

Many researchers have investigated the behavior of carbon nuclei and the other two allotropes of carbon, graphite and diamond, thoroughly over the last 50 years. A detailed introduction to the behavior of carbon in the form of diamond is in two reference books; The Properties of Diamond, edited by J. E. Field; Academic Press Inc.; San Diego, CA 92101; 1979; ISBN 0-12-255250-0 and a subsequent update; The Properties of Natural and Synthetic Diamond, edited by J. E. Field; Academic Press Inc.; San Diego, CA 92101; 1992; ISBN 012-255352-7. These books reference hundreds if not thousands of neutron activation experiments. There is no mention of any carbon sample producing beta particles with a half-life near 10.25 minutes. The only radioactive specie expected from the thermal neutron activation of diamond is ^{14}C with half-life of 5700 years. This is completely consistent with the data available from the Brookhaven National Laboratory web site. The production of ^{14}C is slow due to the long half-life. ^{14}C is difficult to observe in short neutron irradiation tests such as the applicants use in their procedure. When it forms, ^{14}C reveals itself through unique gamma emissions.

Carbon atoms do not form chemical bonds with free neutrons on their surfaces. Carbon crystals, either graphite or diamond, do not trap free neutrons within their interstices. If either of these phenomena occur, graphite or diamond would show the same beta decay half-life the applicants detect after a neutron irradiation experiment with fullerene molecules. The references contain no such reports or claims. The applicants' own experiments with diamond show no such activity.

Fullerenes are unique in the fact that the molecules form a dense cage-like structure. They are also very unusual in that the cage itself is super-conducting surface. One of the characteristics of a super-conducting surface is that it will reflect any imposed magnetic field.

Neutrons possess magnetic fields. Once it is inside the internal cavity of a fullerene molecule, the reflection of its own magnetic field off the interior wall of the fullerene molecule drives the neutron toward the center of the fullerene's internal cavity. The super-conducting surface and the internal cavity are unique to fullerenes as far as the applicants are aware.

> Contention: As noted by the Board in their decision in parent case SN 08/376846, page 112 of Jimenez-Vazquez indicates that although some tests may indicate that a substance is bonded to a fullerene, these tests do not necessarily prove that the substance is within the fullerene.

As already discussed above, there is no art that allows neutrons to exist outside a nucleus, in ordinary conditions for more than a fraction of a second. When one discounts, through current art, all other possible configurations of fullerene molecules and neutrons, the only remaining possibility is that the interior cavities of the fullerene molecules trap the free neutrons. The rules of logic permit a proof based on the elimination of all competing explanations. Once one eliminates all other explanations, the sole remaining explanation must be true. If the process in the application did not produce any result, there would be no observable neutron beta decay radiation to explain in the applicants' procedure.

The examiner originally cited Jimenez-Vazquez as prior art that inherently contained the art in the applicants' specification. The Board of Patent Appeals reversed the examiner's ruling. Jimenez-Vazquez does not discuss trapping free thermal neutrons within the interior cavity of a fullerene molecule. Why does the examiner cite this paper when it does not pertain to the art claimed by the applicants?

Case SN 08/376846, page 112 of Jimenez-Vazquez discusses an isotope of the chemical element hydrogen, e.g., tritium. The experiment establishes that the tritium either attaches to the interior wall of the fullerene molecule, or remains trapped within the interior cavity of the fullerene molecule. Since tritium may form chemical bonds, this dilemma cannot be logically

resolved for tritium within the limitations of the experiment in Jimenez-Vazquez. In the case of thermal neutrons, as noted earlier, there is no art indicating neutrons form chemical bonds. Accordingly, Jimenez is not relevant.

Contention: Kosvintsev et al on page 43 indicate that neutrons inside a trap can be absorbed by the walls of the traps.

The textbook references cited by the applicants, Golub and Ignatovich, also discuss this problem. All neutron traps in all the references cited by the examiner are macroscopic. Their walls, usually graphite, rely only on the small capture cross-section of carbon nuclei to minimize the number of neutrons lost to capture. This is one reason why these experiments are difficult. The electron cloud around the carbon nuclei in graphite is about 0.7 angstrom thick according to The Handbook of Chemistry and Physics. Like other ordinary materials graphite cannot keep the neutrons more than about 0.7 angstrom away from the carbon nuclei. This is well within the de Broglie wavelength of free neutrons at or below room temperature. It is relatively easy for the carbon nuclei to capture these neutrons because they are so close to the carbon nuclei. As was discussed earlier, the extraordinary conditions inside the interior cavity of a fullerene molecule do not suffer from this problem because of the distance from the center of the cavity to the carbon nuclei. This is the characteristic, unique to fullerene molecules as far as is known, that allows them to trap free thermal neutrons in their interior cavities.

Contention: The "example" set forth on pages 7+ of the specification is insufficient as it is not clear from the example as to exactly what the conclusion recited on page 9 lines 18-30 (i.e. that the radiation detected was from the decay of free neutrons trapped inside the fullerenes) is based on.

For example, the actual steps recited in the specification (e.g. see pages 7+) are too vague and incomplete to enable one to make a proper and accurate analysis of exactly what was done, what was detected, etc.

The applicants submit that there is no basis whatsoever for the examiner's assertion and the assertion conflicts with the Talnagi affidavit. The steps in the procedure describe an experiment where neutron irradiation first activates the sample material. The gamma spectrometer identifies the sources of the observed radiation. Using a standard laboratory technique known as "data stripping," the relative abundances of the sources of the observed radiation are calculated. It is the fact that the sum of the radiation from these sources is significantly less than the observed total that is significant. One deduces that the difference between the calculated and observed total radiation is due to the decay of trapped neutrons. Were the difference due to any other known source, the gamma spectrometer would identify it. Once identified, its initial abundance could be calculated. The total of the calculated activities would match the total measured activity.

The exact process, used above, of measuring the relative abundances of contaminants in a sample is explained in Activation Analysis by Miloslav Rakovic translated by D. Cohen; CRC Press 1970; Library of Congress Catalog Card Number 71-107282; pp191 to 194. Another reference is Guide to Activation Analysis edited by William S. Lyon, Jr.; D. Van Nostrand Company, Inc. 1964; Library of Congress Catalog Card Number 64-23964; pp131 to 133.

Neutron irradiation, data stripping and the identification of sources of radiation by a gamma spectrometer are second nature to persons with the training and experience of Mr. Talnagi. He has signed a notarized affidavit that he performed the experiment as specified by the applicants and obtained the same results as the applicants.

> Contention: There is no indication of the various possible errors and sources of errors including systematic errors, cumulative errors, instrumentation errors, etc. Such is necessary in determining the validity of the applicants' conclusions or interpretation of the experimental results.
>
> This interpretation or, even inadvertent misinterpretation of experimental data, as the case may be, goes to the heart of the matter. In any experiment, there

> will be errors (due for example, to the instruments themselves since no instrument is 100% error free) and, there is data which must be collected and interpreted.
>
> Further, in any experiment there will be errors introduced due to systematic or cumulative errors, as well as instrument errors since all instruments have some error in their measurements, the amount of error being dependent for example on the type and quality of instrument.
>
> Clearly, if the results fall within the limits of experimental error, the results are of no probative value.
>
> In the present case, applicants have not identified all of the various errors nor, have applicants shown that their results fall outside the error limits.

The applicants do not see the relation between the level of "enablement" in the patent application and non-specific questions about the amount of error in the example experiment provided in the application. The example illustrates the procedure that produces verifiable positive results. There is no evidence in the record that would suggest that applicants' results are within the limits of experimental error. The contention is purely speculative and is not a proper basis for rejection under §112.

The applicants find no lengthy discussions of "possible errors and sources of errors including systematic errors, cumulative errors, instrumentation errors, etc." in any of the patents cited by the examiner. Ohio State Nuclear Reactor Laboratory regularly calibrates the instruments used in this experiment. A measurement of the background radiation affecting each instrument precedes and follows each experiment as a matter of routine laboratory procedure. The background radiation measurements alone would indicate any serious instrumentation problem since they are known to vary little from experiment to experiment. Other researchers use these same instruments to run many other experiments. They have never noticed any unusual behavior. The data stripping technique is self-correcting for small experimental errors. The result it would yield in the case of serious uncertainty in the measured beta decay radiation would be no difference between the observed and calculated radiation level.

The data from many experiments are consistent and repeatable. The applicants take great care to avoid sources of error. As noted above, the instruments are in calibration. They are also in constant use. Any sample whose gamma spectrum exhibits radiation from an emitter with a half-life greater than 2.5 minutes and less than 55 minutes is not used in an experiment. The applicants' experimental results are consistent with an emitter whose half-life is 10.25 minutes +/- 2 minutes. The intensity of the claimed neutron decay radiation is always orders of magnitude above background. In all experiments, its initial abundance is within an order of magnitude of the contaminant emitters. In some samples, it is initially the most abundant emitter.

> Contention: In this same vein, the examiner has shown that gross beta counters (used by applicants in obtaining their results as indicated by page 8 of the specification) are susceptible to more than just betas and gammas (see page 390 of Boaz et al as evidence).
>
> This in itself could introduce errors which could negate applicants interpretation of their data as being indicative of the presence of trapped thermal neutrons.

The entire point of the "data stripping" process, previously discussed in detail, is to remove the influence of the identified contaminants in the sample from the gross beta counter data. The fact is that after the removal of this influence by the process of "data stripping" there remains a significant amount of radiation. This radiation has a half-life comparable to that of free thermal neutrons. Its half-life is not comparable to any contaminant emitter identified by the gamma spectrometer. Other than free thermal neutrons, there are no known emitters produced by thermal neutron irradiation of naturally occurring isotopes that, simultaneously, are not identifiable by a gamma spectrometer, have a half-life of about 10 minutes, and are detectable by a gross beta counter.

> Contention: As a further possible source of error, it is noted that Jimenez-Vaquez et al in the first column on page 113, state it is not known how much the C_{60} cage

can shield the emission of a beta particle (which is what applicants are attempting to detect).

The examiner is correct. It is very likely that the fullerene cage partially shields the beta emission from the decay of the trapped thermal neutron. This may attenuate the strength of the beta radiation resulting from the decay of the trapped thermal neutron. It cannot change the observed half-life of the beta radiation emitted by the decay of the trapped thermal neutron. The only quantity that this possible shielding effect can change is the observed abundance of the trapped thermal neutrons. Since the thermal neutron decay beta emission is observable and their observed, initial intensity is often the largest in the sample, any shielding by the fullerene cage does not affect the applicants' conclusions. If the fullerene molecule completely shielded the beta radiation, there would be no difference between the calculated and measured radiation intensities.

Contention: While the example in the specification indicates the empty vial was weighed, there is no indication that the "sample" was weighed before being placed in the vial, after being placed in the vial, after irradiation and after removal from the vial.

The disclosure is insufficient as to the isotopic content of the "sample" (including all impurities and/or contaminants present).

Such is clearly pertinent to the patentability of applicants invention since these impurities and/or contaminants could be made radioactive by the neutron irradiation and, if they are beta or positron emitters with a half life on the order of 10 minutes, give a false indication of the trapping of thermal neutrons in the fullerenes.

Note in this respect that Braun et al in the second column on page 443 state that commercial fullerenes contain non-negligible amounts of impurity elements which can be made radioactive (activated) by neutron irradiation all of which can lead to erroneous results.

The applicants consider themselves authorities on the detection and characterization of the impurities in fullerenes as a result of our efforts to develop the art in the application. We spent three years obtaining fullerene samples that were pure enough to permit our experiments. The net effect of excessive fullerene impurities on the art in the application is a negative result.

Excessive radiation from impurities tends to obscure any emissions from the decay of trapped free thermal neutrons. It was only after suppliers developed processes that produce high purity fullerenes that these experiments became consistently successful.

The only contaminants that can affect the applicants' procedure are those that are activated by thermal neutron irradiation. Some trace contaminants, such as non-fullerene carbon, hydrocarbon solvents such as the acetone used in the fractionation of the fullerenes and atmospheric gasses other than ^{40}Argon, do not activate. Thus, they do not radiate gamma rays or beta particles and do not affect the applicants' results and conclusions.

The contaminants that do activate are the entire reason for the "data stripping" process described at length elsewhere. If these impurities were not present, "data stripping" would be unnecessary. The pure beta emission with the half-life characteristic of free thermal neutron decay would be directly observable.

> Contention: In further regard to this issue of impurities and/or contaminants, it is noted that applicants in part (d) on page 6 of the brief in parent case 08/376846, state that in their experiments, the contaminants varied from sample to sample and sometimes from test to test of the same sample! Such additionally makes it appear that the 'sample" could become contaminated at any point during the experimental procedure and, thus, also introduce errors.
>
> If the experimental procedures are such that contaminants can be so introduced (particularly from test to test of the same sample), any conclusions drawn from these experiments would be suspect.

This is a misrepresentation of the applicants' statements. The only time that a contaminant can become activated by thermal neutron irradiation is during the time it is in the thermal neutron flux of the reactor. Once a sample leaves the reactor flux, any contaminant entering the sample as a result of handling would not be activated and would thus remain undetectable. Therefore, the contaminants of concern to the applicants cannot change during an experiment. The applicants never stated that they could. We do take multiple gamma spectra of the same sample during the course of the procedure to be certain that short half-life emitters are not

masking long half-life emitters. We are not worried that the contaminant emitters themselves change during an experiment.

Contaminants introduced during an experiment but after the sample leaves the reactor can affect only subsequent experiments when a subsequent exposure to the thermal neutron flux of a nuclear reactor activates the contaminants. This has happened. The result was that the applicants discontinued the subsequent experiment and discarded the sample. The only reason that applicants reused samples was to prove that the results were repeatable with the same sample. We were successful.

Neutron activation is one of the most sensitive tests for the presence of many chemical elements known. It is easy to introduce contaminants into a sample during handling with even the most stringent procedures. A microscopic particle of dust from the atmosphere being included in a sample before neutron irradiation is enough to corrupt the results of an experiment. Touching the sample with a clean steel tool can introduce unacceptable levels of iron into the sample.

That this has happened does not affect the applicants' over-all results or the patentability of this invention. Samples with excessive contamination will reliably yield negative results and we discard them. We also discard samples with contaminants with half-lives between 2.5 and 55 minutes. The applicants have explained these precautions to the examiner in previous correspondence. The applicants do not understand how the examiner can construe these stringent and expensive precautions as a deficiency in the application or the procedure.

> Contention: There is no indication of why the various time periods indicated in the example on page 7 of the specification, were utilized.
>
> It is not clear from the "example" as to exactly when the first gamma analysis is performed. However, it appears that there is an initial "window" of at least 14-15 minutes (or even over 30 minutes (see step 8)) after removal from the neutron flux before gamma analysis is performed, and thus, gamma emitters with

shorter half lifes would presumably be considered as beta emitters and, as erroneous evidence of free thermal neutrons trapped in the fullerenes.

The applicants have explained these times to the examiner in previous correspondence.

The applicants selected the times in the example on page 7 for the following reasons:

1. *In Step 2, the first beta counts lasted a total of 12 minutes. They allow any short half-life contaminants, e.g., those contaminant emitters with half-lives less than 2.5 minutes, enough time to decay out of the sample. The 12-minute length of this step gives these emitters at least five half-lives to decay. These data are also available to check the initial behavior of the emitters in the sample after all data reduction is complete. In a clean sample with no short half-life emitters, they will show the same 10.25-minute half-life as subsequent data. They will never fall below the 10.25-minute half-life beta activity of subsequent reduced data. If short half-life emitters are present, these data are not used.*

2. *In Step 3, the example takes the first gamma spectrum after twelve minutes. It verifies that the short half-life emitters are gone from the sample. It also verifies the absence of any emitters with half-lives between 2.5 and 55 minutes. Lastly, this spectrum identifies any contaminant emitters with half-lives longer than 55 minutes. Note that the decay of free thermal neutrons has no associated gamma emission. The gamma spectrometer cannot detect the decay of any trapped neutrons. The applicants do not expect it to do so. If emitters with half-lives between 2.5 and 55 minutes are present in the sample, the experiment ends at this point, the sample is discarded, no data is reduced, and no conclusions are drawn.*

3. *In Step 4, after taking of the gamma spectrum, the sample returns to the beta counter for another 12 minutes of beta activity measurement. This set of beta activity data is the data set reduced by the data stripping process.*

4. *Step 5 takes a second gamma spectrum as a confirmation of the first spectrum. Any inconsistencies between the first and second spectrum result in the experiment ending and the discarding of the sample.*

5. *Steps 6 and 7 collect data for the data stripping process. The contaminants present in the sample as determined by the gamma spectra set the schedule for these data collections. The requirement is to collect beta activity at five half-lives of each successive long half-life emitter save the longest.*

6. *Step 8 determines whether the first set of beta activity data is usable. The gamma spectrometer is more sensitive than the gross beta counter, and very slight* ^{28}*aluminum emissions may still be detectable in the gamma spectrometer even after five half-lives have passed since the sample left the neutron flux.*

7. *Step 9 strips the beta activity of each respective long half-life emitter from the total beta activity recorded during the second twelve minutes in the gross beta counter.*

8. *Step 10 examines the remaining beta activity in the second, total, beta activity, data set after stripping of all beta activity attributable to contaminants out of it. What remains will have a 10.25-minute half-life +/- 2 minutes.*

The delay between the exit of the sample from the reactor flux and the first data collection from the gross beta counter has a two-fold purpose. First, the applicants allow time for any short half-life, less than 2.5 minutes, emitters to decay out of the sample. Once they have decayed for five or more half-lives, they are no longer detectable. The most common, short half-life, contaminant emitter is ^{28}Aluminum. The second reason for the delay is to allow time to collect a gamma spectrum to confirm the short half-life emitters are gone and to identify any longer half-life contaminant emitters. If any detected emitters have half-lives between 2.5 an 55 minutes, the applicants end the experiment and discard the sample.

The usable series of data collections from the gross beta counter begins when the ^{28}aluminum and other short half-life emitters have decayed out of the sample as indicated by minimal to no ^{28}aluminum gamma activity detected by the Gamma spectrometer. These initial beta activity data collections establish the total activity of all radiation from all emitters in the sample that registers in the gross beta counter. This total may include any form of radiation. The specification schedules one of these data collections every 2 minutes starting when the short half-life emitters have decayed.

The subsequent gross beta counter data collection times are as follows. The first one occurs at five half-lives of the unknown emitter. This data collection determines the total activity detectable by the gross beta counter once all the presumed neutrons have decayed out of the sample.

The long, half-life, contaminant emitters actually detected by the gamma spectrometer during the initial gamma spectra collection set the collection times for the remaining beta activity data. These times cannot be set until gamma spectrometer identifies the long half-life emitters after the thermal neutrons irradiate the sample. These times are set equal to five times

the half-life of each emitter. The exception is the contaminant emitter with the longest half-life. No data collection is necessary for the contaminant emitter with the longest half-life.

Once the above data collection times are set, it is simply a matter of measuring the total activity detectable by the gross beta counter at each time. When collection of all the data is complete, the relative initial abundance of each contaminant emitter is calculable using the method described in Rakovic and Lyon that the applicants call "data stripping."

The calculation of the initial abundance of each emitter proceeds as follows. At the last scheduled data collection time, that is five times the half-life of the emitter with the second longest half-life, the only beta activity present is that of the emitter with the longest half-life and the background activity. The measured activity minus the background activity is the activity due to the contaminant with the longest half-life. Since the gamma spectrum has already identified this emitter, it is easy to calculate its initial abundance based on the published half-life and the measured activity at a known time. Once the initial abundance is calculated, the activity of this particular emitter may be calculated and subtracted from all the other beta activity observations. Repeat this process until each identified long half-life emitter's activity is subtracted from each observed, total, beta activity data set.

When the subtraction process described above is complete, the total beta activity in each data set will be approximately zero for the data sets longer than 55 minutes. The data sets shorter than 55 minutes will still exhibit residual beta activity. An exponential decay curve fit to this residual activity will have a half-life of approximately 10.25 minutes +/- 2 minutes.

This activity corresponds to no known emitter with a half-life between 2.5 and 55 minutes. No samples exhibiting such emitters are tested. The emitter responsible for this activity is detectable by a gross beta counter but not by a more sensitive gamma spectrometer. This means

that this emitter emits beta particles but no gamma rays, e.g., a pure beta emitter. Finally, the irradiation of the sample with thermal neutrons created this emitter.

Thermal neutron irradiation of naturally occurring elements has strictly limited abilities to create radioisotopes. The only radioisotopes created from naturally occurring elements in any significant abundance are those with mass numbers, A, one unit above a stable, naturally occurring isotope. No such thermal neutron-activated isotope is both undetectable by the gamma spectrometer and has a half-life between 2.5 and 55 minutes.

The only known emitter of beta radiation that fits all of the above criteria is a trapped free thermal neutron. Previous discussion explains why these thermal neutrons must be located inside the interior cavity of a fullerene molecule.

This, then, is the process of data stripping. It explains how the influence of emitters, other than free thermal neutrons, is eliminated from the raw data. This process is basic to the art of neutron activation analysis.

One with ordinary skill in the art would not require such detailed instructions. The only instruction they would need is that they must prove a sample contains a pure beta emitter with a half-life of 10.25 minutes. With nothing more, they would be able to develop the above experimental procedure. Mr. Talnagi is such a person. He did just that. He wrote the original instructions for the applicants under contract. The applicants reproduced the experimental results with Mr. Talnagi's instructions, not the reverse. The instructions in the application are far more detailed than needed by a person of ordinary skill in the art.

The applicants again note that similar, lengthy discussions have been part past correspondences with the examiner. We repeat it here for his convenience.

Contention: The example is insufficient in failing to set forth all of the contaminants and impurities detected during the analysis (including any contaminates whose decay could be mistaken for the decay of free neutrons). Such would be useful in determining the accuracy of applicants conclusions concerning the experimental results.

The applicants submit that this requirement goes well beyond the requirements of §112. As discussed at length above, the contaminants that the gamma spectrometer may detect are unknown before the experiment is underway. Only after the thermal neutron flux of the reactor activates the sample and collection of the gamma spectrum is complete, can any discussion of the contaminants occur. The example sets out the experimental procedure. It is not possible to include the information the examiner requests in an experimental procedure since the applicants can not know the contaminants in advance of an experiment. In the experiment described in the example, ^{28}aluminum, ^{24}sodium and ^{41}argon were the only contaminants detected by the gamma spectrometer.

The applicants emphasize that the delicacy of the experiment demands the use of only the highest purity fullerene samples. The samples in all of the applicants' experiments have always been the highest purity fullerenes available. The contaminants in the example have three sources. ^{40}Argon is a component of the atmosphere. The form of the fullerene sample is similar to very fine sand. The spaces between the grains of the sample trap some atmospheric ^{40}argon atoms. The exposure to the thermal neutron flux of the reactor activates some of the ^{40}argon between the fullerene grains into the ^{41}argon detected in the experiment. The applicants did perform one experiment where they isolated the sample from the atmosphere until after the exposure to neutron irradiation. This particular experiment also exhibited the 10.25-minute half-life beta activity that is characteristic of free neutron decay. This experiment was not repeated because of the difficulty and expense involved.

In other experiments, such as the one in the example in the application, the applicants seal the sample inside a sealed vial during all data collection after the exposure to the thermal neutron flux in the nuclear reactor. This prevents the activated ^{41}argon from escaping the field of view of the detector. If it did escape, this effective loss of the emitter from the sample could mimic the decay of a non-existent emitter. We use the sealed vials during data collection to avoid the escape of any volatile emitter from the sample.

The activated ^{28}aluminum isotopes in the samples are from the apparatus used to manufacture the fullerene molecules. Both the formation and fractionation of the fullerene molecules take place in vessels made mostly of aluminum. Bare aluminum will always form a thin layer of aluminum oxide on its surface. We believe particles of aluminum oxide are included in the sample material either during their creation or during fractionation leading to the persistent ^{28}aluminum emission in the experiments.

Similarly, the applicants also think the activated ^{24}sodium is also an inclusion that results from glass equipment used in the fractionation of the fullerenes. In general, it is very difficult to avoid the trace contaminant sodium. It is everywhere. These contaminants have half-lives different enough from the half-life of free neutrons that they are easily stripped out of the sample. The applicants explained the method used to strip the influence of these contaminants out of the samples earlier. Contaminants are not the source of the 10.25-minute half-life, beta activity in the fullerene samples.

> Contention: The specification on page 9 indicates that there are some pure beta emitters with a half life on the order of 10 minutes. However, it does not appear that such emitters were searched for in the "sample". The disclosure is insufficient as to how and in what manner it was ensured that there were not present any other beta emitters (including non-pure beta emitters or beta emitters which also emit other radiation) with a half life on the order of 10 minutes. The examiner in parent case SN 08/376846 had pointed out to applicant that there are other beta emitters including pure beta emitters (as well as positive beta (positron) emitters) which

have a half life of around 10 minutes, e.g. As- 79, Rb-91, Mo-102, Cs-139, Ho-154, Ce-131, Cd-119, Fe-53, Cu-59, N-13.

As discussed above, the only radioisotopes that occur through neutron activation of natural elements are those with an "A" number one unit greater than the "A" number of a stable, naturally occurring isotope. No isotopes simultaneously fit all these additional, necessary criteria. They must have a half-life of approximately ten minutes. They must have no strong gamma emissions themselves and they must have no sister isotopes, nuclei with the same "Z" number but different "A" number, that are detectable through their gamma emissions. None of the radioisotopes cited above by the examiner fit these criteria. None of the radioisotopes cited by the examiner occurs by the addition of one neutron to a stable naturally occurring isotope.

Appendix D of Nuclear Techniques in Analytical Chemistry by Alfred J. Moses; Pergamon Press Limited 1964; Library of Congress Catalog Number 64-15736 lists the product isotopes that result from thermal neutron irradiation of naturally occurring isotopes. None of the isotopes suggested by the examiner appears on this list.

Fast neutron reactions produce only one of the isotopes suggested by the examiner, ^{13}N. Particle accelerators are the only way to produce the rest. The applicants do not use a particle accelerator in the example procedure. The applicants choose the location in the nuclear reactor used to activate the fullerene samples specifically to avoid any population of fast neutrons. Any production of ^{13}N in the applicants' procedure would be so small as to be undetectable by the gross beta counter. None of the contaminants suggested by the examiner accounts for the strong 10.25-minute half-life, beta decay activity that the applicants' observe in their experimental procedure.

Contention: Nucleonics and Hodgeman et al also indicate there are numerous beta emitters (both negative and positive) having a half life close to 10 minutes, any of which could cause interference and lead to erroneous results or a

misinterpretation of experimental results. It is not seen wherein applicant has accounted for such.

The applicants do not dispute that it is theoretically possible that some isotopes could masquerade decaying of free thermal neutrons. The applicants dispute that such an isotope can result from the addition of one neutron to any stable, naturally occurring isotope, e.g., simple thermal neutron activation as discussed by Moses. Further, this hypothetical isotope must have no detectable sisters. A thorough search of the National Nuclear Data Center website maintained by Brookhaven National Laboratory supports this argument. If it is not possible for such an isotope to be present in the sample after neutron irradiation, then the inability to search for it is not a deficiency.

Contention: The disclosure is insufficient as to how and in what manner, the neutrons can be entrapped by controlling the temperature of the fullerenes.

The applicants are not suggesting, that temperature is a controlling factor in producing fullerenes having trapped neutrons. As discussed earlier, all other reactions involving the trapping of particles and atoms inside fullerenes are temperature or energy dependent. It is reasonable to assume reactions involving neutrons are similarly dependent. As explained earlier, there is a minimum energy for the incident neutron and a maximum energy for the incident neutron where the fullerene molecule may trap the neutron. In general, all physical or chemical reactions are dependent upon temperature or energy in some manner. The applicants are simply acknowledging this fact.

For the reasons set forth above, applicants request that the rejections be withdrawn and this case passed to issue.

Respectfully submitted,

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